



Research

Peatland and wetland ecosystems in Peruvian Amazonia: indigenous classifications and perspectives

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ABSTRACT. Many indigenous people hold detailed ecological knowledge about their environment and have developed complex classifications of ecosystem types in their own languages. These classification systems may be based on characteristics including the availability of key resources, salient plant species, and cultural factors, among others. Indigenous environmental knowledge has been of interest to (ethno-)ecologists, geographers, anthropologists, and other scientists looking to learn from indigenous people, especially in newly emerging research topics. We identified and interpreted an ecosystem classification system of the Urarina, a small indigenous nation based in the Chambira River basin, a peatland-rich area of Peruvian Amazonia. Our findings, based on semistructured interviews, participatory mapping exercises, and site visits, indicate that the Urarina distinguish between ecosystems according to vegetation physiognomy, certain (palm) tree species, hydrology, and soil appearance, and that their use of natural resources varies between different ecosystems. Two Urarina ecosystems, *jiiri* and *alaka*, are almost certainly associated with the presence of peat soils and are of special cultural significance. The Urarina ecosystem classification system thus offers insights and inspiration for ecologists studying peatlands and other wetlands in the Peruvian Amazon who, thus far, have mostly focused on floristic and structural analyses only. Not least, our research highlights the importance of the peatlands for local people, beyond their role for the global climate system as a substantial carbon store.

Key Words: *Amazon; ecosystem classification; indigenous knowledge; Peru; tropical peatlands; Urarina*

INTRODUCTION

Through millennia of experience and interaction with certain environments, many indigenous peoples have developed sophisticated and culturally specific environmental knowledge systems (Berkes et al. 1998, Davidson-Hunt and Berkes 2003, Folke 2004, Sileshi et al. 2009). These knowledge systems express themselves not just in the information that indigenous people hold, for example, about traditional medicinal plants, game species, or climate patterns, but also in their daily practices and in their wider beliefs and worldviews, often termed cosmovision, cosmology, or “kosmos” (Toledo 1992, Toledo and Barrera-Bassols 2009). One important element of indigenous environmental knowledge systems is the classification of habitats, ecosystems, or landscapes (Berkes et al. 1998, Omotayo and Musa 1999, Shepard et al. 2001, Davidson-Hunt and Berkes 2003, Duvall 2008, Levinson 2008, Johnson and Davidson-Hunt 2011, Molnár 2013, Wartmann and Purves 2018). Such classification systems rely on various indicators to delimit boundaries between spatial units. These may be related to the vegetation, e.g., the presence of certain salient plant species, or abiotic factors such as soil types, hydrology, or topography of an area. Studies of indigenous classification systems have been conducted in many different contexts around the globe, e.g., to identify rain forest habitats with the Matsigenka of the Peruvian Amazon (Shepard et al. 2001), habitat types recognized by traditional herders in the Hungarian Hortobágy salt steppe (Molnár 2013), physical geographic concepts of Maninka farmers in Mali (Duvall 2008), or the landscape and seascape terminology of the inhabitants of Rossel Island, Papua New Guinea (Levinson 2008).

Interest in indigenous knowledge systems remains strong among ethnoecologists, anthropologists, geographers, environmental social scientists, and policy makers (Pascual et al. 2017, Tengö et al. 2017), even if the boundaries between indigenous and nonindigenous knowledge remain the subject of considerable academic debate (Agrawal 1995, 2009, Leach and Fairhead 2002, Ludwig 2016, 2017, Löfmarck and Lidskog 2017). Studies of indigenous knowledge, including ecosystem classification systems, are considered to be important for at least four reasons:

1. Understanding indigenous ecosystem classifications contributes to making sense of the underlying worldviews that shape naming practices in the first place (Hunn 1996, Duvall 2008, Levinson 2008). Associated with this, linguists, ethnogeographers, and others have made attempts to formulate general theories of place-naming practices (e.g., Hunn 1996, Smith and Mark 2003, Levinson 2008).
2. Indigenous knowledge is frequently viewed as the cultural heritage of indigenous nations that may potentially be lost through processes of cultural assimilation into dominant mainstream societies (Shepard et al. 2001, Hance 2015, Ens et al. 2016). Its documentation through academic research may safeguard this cultural heritage for its intrinsic value, as well as for potential use in education and cultural engagement activities.
3. Indigenous knowledge may be a potential “shortcut” for the development of conventional science, e.g., where local people may have more detailed knowledge of local ecosystems and species than foreign ecologists or a better

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understanding of habitats at a local scale (Fleck and Harder 2000, Shepard et al. 2001, Sheil and Lawrence 2004). It may also function as a reference for comparison, dialogue, and a benchmark for the quality of scientific knowledge via ground truthing and cross validation (Robbins 2003, Fernández-Llamazares et al. 2017, Reyes-García et al. 2018), e.g., where local forest types defined by indigenous people are compared with habitat types identified through remote sensing and statistical ecological analysis (Abraão et al. 2008).

4. Awareness of indigenous knowledge is often considered useful for improving environmental management (Stevenson 1996, Berkes et al. 2000, Puri 2007, Sileshi et al. 2009, Steele and Shackleton 2010, Armatas et al. 2016). Sometimes this may be because of its capacity to increase exploitation and production of natural resources, e.g., by increasing agricultural yields via an improved understanding of soil diversity (Rainey 2005, Pereira et al. 2017). It may also inform and strengthen environmental conservation partnerships with indigenous people by adapting conservation measures to local knowledge systems and thereby increasing their acceptance by indigenous partners (Chapin 2004, Sheil and Lawrence 2004, Ens et al. 2016).

Although some authors have stressed a need for describing indigenous knowledge purely on its own terms (e.g., Duvall 2008), most studies in the field still aim to achieve varying levels of dialogue, comparison, or complementarity between indigenous and “scientific” knowledge, not least because boundaries between the two types of knowledge are inevitably arbitrary (Robbins 2003). Evidence of the arbitrary distinction between knowledges is that indigenous knowledge is considered useful for scientific knowledge in the first place, although Ludwig (2017) cautions that there is a risk of crowding out those aspects of indigenous and local knowledge that are deemed “not useful” by Western scientists. Some authors may also prefer the term “science-based knowledge” instead of “scientific knowledge” (e.g., O’Flaherty et al. 2008), possibly to highlight that the boundary between the different knowledge systems is primarily defined by the application of scientific methods. In line with Raymond et al. (2010), we define “indigenous knowledge” as knowledge held by a certain indigenous nation, and, following Andolina et al. (2009:178), we understand it “in sociocultural, relational terms instead of space-bound understandings that fix knowledge to particular local areas.” In this way, we place an emphasis on diverse ways of knowing and processes of learning, where dialogue can be generated between different knowledge communities, across the diversity among indigenous communities, as well as conventional (Western) science.

We contribute to the literature on indigenous ecosystem classification systems with a study of Urarina classifications of their environment in the Loreto Region of Peruvian Amazonia. The Urarina are an indigenous nation of about 3000 members who live in small communities in the Chambira River basin of the Peruvian Amazon, in the challenging environment of nutrient-poor blackwater river systems and associated wetlands, swamps, and seasonally flooded forests, with little perennially

dry land (Kramer 1979, Witzig and Ascencios 1999, Olawsky 2006, Roucoux et al. 2017). Urarina ways of classifying their environment might be of global relevance, given that they live in the midst of what appears to be the largest peatland complex in Amazonia, only recently recognized as such by physical geographers and ecologists. Other tropical peatlands of global relevance are located in the Congo Basin (Dargie et al. 2017) and in Southeast Asia (Couwenberg et al. 2010), and the latter are under threat from fires (Turetsky et al. 2015) and conversion to agriculture, such as oil palm plantations (Koh et al. 2009). The large quantity of carbon processed and stored by these peat-forming wetlands means that they are a significant component of the global climate system (Freitas Alvarado et al. 2006, Lähteenoja et al. 2012, Draper et al. 2014, Roucoux et al. 2017). Thus, we placed special emphasis on identifying whether the boundary between peatland and nonpeatland ecosystems was meaningful to the Urarina.

It has sometimes been suggested that the difficult environment of peatlands has acted as a natural barrier or “shelter” that has helped to maintain the cultural integrity of the Urarina since colonial times (Witzig and Ascencios 1999), even if there are marked differences between different settlement areas, depending on their accessibility (Kramer 1979). Peatlands around the globe play an important part in the cultural imaginary of people who live close to them, because of their distinct physical and ecological features (Lehtinen 2000, Byg et al. 2017), although this aspect tends to be underexplored for tropical peatlands so far. Research on local ecosystem classifications has not yet systematically explored whether terminology for peatland ecosystems exists in indigenous languages, one of the research gaps that we are trying to address. In the Peruvian Amazon, for example, some socio-cultural assessments focus on certain locally known ecosystem types such as *aguajales*, i.e., palm swamps dominated by the palm species *Mauritia flexuosa*, locally known as *aguaje*, which may or may not coincide with the presence of peat in the ground (Gilmore et al. 2013), but there is likely to be some overlap between *aguajales* and peatland ecosystems (Freitas Alvarado et al. 2006).

Previous research in Urarina communities has been conducted by linguists (e.g., Cajas Rojas et al. 1987, Manus 1992, Olawsky 2002, 2006) and by ethnographers and anthropologists (e.g., Tessmann 1930, Kramer 1977, 1979, Díaz Barba 1987, Dean 1994, 1999, 2009, Walker 2013a, b, Fabiano 2015). There are about 2000 speakers of Urarina, an isolated language with unique linguistic features (Olawsky 2006). The Urarina have a long history of oppression and exploitation by their neighbors, which precedes colonization of the area by the Spanish from the 17th century onward (Dean 2009, Walker 2013b). Although they had extended contact with Jesuit missionaries in the 17th and 18th centuries and continue to be visited by North American and Argentinean evangelical missionaries today, they conserve a strong separate cultural identity and are officially recognized as an indigenous nation by the Peruvian state. Previous ethnographic research has considered Urarina agricultural techniques (Kramer 1977, Díaz Barba 1987); socioeconomic interactions with *patrones*, i.e., nonindigenous resource extractors hiring indigenous workers within an asymmetric power relationship (Kramer 1979, Dean 1999); the role of shamans and consumption of hallucinogenic *ayahuasca* (Fabiano 2015); and marriage

patterns, childhood, and adolescence, as well as gender relations (Dean 2009, Walker 2013b). Gender differences are extremely marked (Walker 2013b). For example, only men interact with outsiders, speak (limited) Spanish, wear nontraditional clothes, and have adopted “foreign” pastimes such as playing football. In contrast, most Urarina women do not typically talk to outsiders, do not speak Spanish, do wear traditional clothes, and are, in this way, stewards of the cultural heritage of this indigenous nation (Walker 2013a, b), like women in many other indigenous settings in the wider Amazonian-Andean region (Andolina et al. 2009).

Overall, our aim is to identify and interpret Urarina ecosystem classifications for the first time to help establish the importance of indigenous understandings of peatland and wetland ecosystems to academic debate. This serves several purposes: first, it may help conventional scientists to advance their thinking regarding the classification of ecosystems in the peatland-rich environments where the Urarina traditionally live, the detailed floristic description of which has only recently begun (Lähteenoja et al. 2012, Draper et al. 2018). Second, it gives the first insights into the role and naming of peatlands among local people in the Peruvian Amazon, a research question that has so far not been investigated (Roucoux et al. 2017). Third, it contributes to documenting an aspect of Urarina culture that has so far not been systematically studied, at a time when their cultural heritage is at risk of being lost through weakened interest among younger generations (Olawsky 2006).

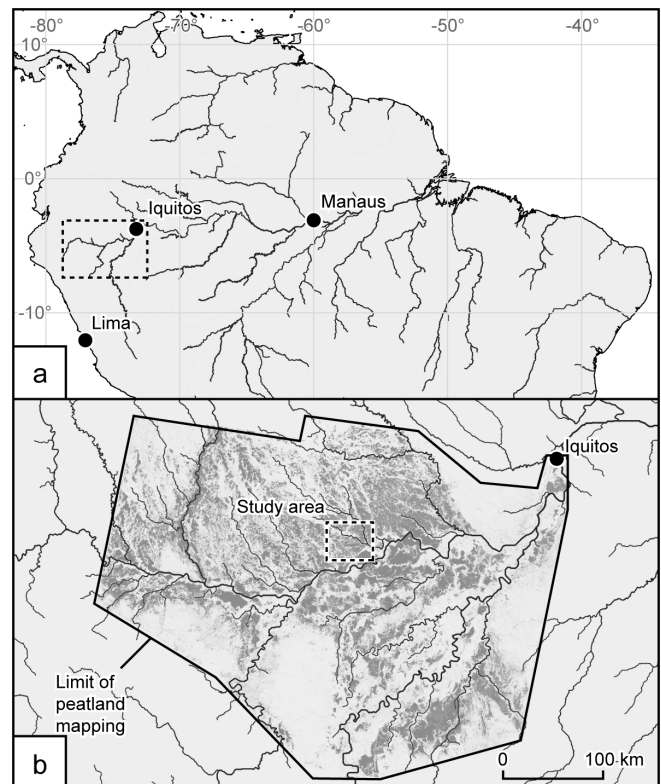
MATERIALS AND METHODS

Fieldwork took place in March/April 2018 in the Urarina community of Nueva Unión, located on the Espejo River, one of the tributaries of the Chambira River, which is part of the wider Pastaza-Marañón Basin in the Loreto Region of Peruvian Amazonia (Fig. 1). It consisted of semistructured interviews with community members, participatory mapping exercises, and site visits, which are established methods for the study of indigenous ecosystem classification systems (Johnson and Davidson-Hunt 2011).

In total, 20 semistructured interviews were carried out collaboratively by the first 4 authors of this article with 27 community members overall, representing roughly a third of the overall adult population of the community. Interviewees ranged in age from 18 to 72 years old and included 20 men who were interviewed in Spanish and 7 women who were interviewed in Urarina with the help of a local translator. All male interviewees engaged in hunting, fishing, and small-scale subsistence farming of manioc, plantain, corn, sweet potato, and other crops (see Table 1 for full species names) or had at least some experience with these activities. The majority were also active in the seasonal trade of palm hearts, locally known as *chonta*, harvested from the wild palm tree species *Euterpe precatoria*, and *aguaje* fruit, from the wild palm *Mauritia flexuosa* (Delgado et al. 2007, Balslev et al. 2008, Smith 2015, Virapongse et al. 2017), and some had been working on the maintenance of an oil pipeline that crosses the community's territory. Further professions represented were two primary school teachers, who earned a salary from the Peruvian state, and a pastor. Female interviewees were in charge of child care, cooking, collection of firewood,

fishing, washing clothes, and production of traditional textiles, among other activities.

Fig. 1. (a) Location of the Pastaza-Marañón Basin in western Amazonia (dashed box); (b) inset showing the Pastaza-Marañón Basin, with the modeled distribution of peatlands following Draper et al. (2014) in gray. The study area, around the Chambira River basin, is indicated.



The main topics covered in interviews, relevant to us, were (1) natural resource use, especially hunting, fishing, and timber and nontimber (forest) product harvesting; (2) classification of the surrounding environment into various ecosystem categories in the Urarina language and their indicators (see *Urarina ecosystem classification* for further details); and (3) cultural and mythological importance of certain ecosystem types and associated traditional beliefs and stories. All interviews were recorded and transcribed in Spanish; analytical categories within the interview transcripts were coded with NVivo 11 to facilitate the qualitative analysis.

These semistructured interviews were complemented with participatory mapping exercises, which were employed as a visual tool to facilitate discussions on the classification of the various areas surrounding the community. One full-day community mapping workshop was held at the beginning of fieldwork, in which 5 groups of 8 to 12 people, separated by gender, worked on 1 large map each to identify a tentative list of Urarina ecosystems that could then be discussed in subsequent interviews. During this workshop, community members described their use of natural resources, as well as the terrain surrounding their community.

Table 1. List of species.

Scientific Name	Local Spanish Name	English Name or Approximation
<i>Alouatta seniculus</i>	<i>Coto</i>	Venezuelan red howler
<i>Attalea butyracea</i>	<i>Shebón</i>	A palm tree
<i>Biotodoma</i> sp.	<i>Bujurqui</i>	Cichlid fishes
<i>Bradypus variegatus</i>	<i>Oso perezoso</i>	Brown-throated sloth
<i>Brycon</i> sp.	<i>Sábalo</i>	Brycon (a fish)
<i>Caiman crocodilus</i>	<i>Lagarto blanco</i>	Spectacled caiman
<i>Calophyllum brasiliense</i>	<i>Lagarto caspi</i>	A tall hardwood tree
<i>Calycophyllum spruceanum</i>	<i>Capiróna</i>	A hardwood tree
<i>Cedrela odorata</i>	<i>Cedro</i>	A tall timber tree
<i>Chelonoidis denticulata</i>	<i>Motelo</i>	Yellow-footed tortoise
<i>Choloepus hoffmanni</i>	<i>Oso perezoso</i>	Hoffmann's two-toed sloth
<i>Copaifera officinalis</i>	<i>Copaiba</i>	Hardwood trees
<i>Coussapoa</i> sp.	<i>Renaco</i>	Hardwood trees
<i>Cuniculus paca</i>	<i>Majás</i>	Lowland paca
<i>Dasyprocta fuliginosa</i>	<i>Añuje</i>	Black agouti
<i>Dasyprocta</i> sp.	<i>Carachupa</i>	Armadillo
<i>Dracaena guianensis</i>	<i>Camaleón</i>	Northern caiman lizard
<i>Eunectes murinus</i>	<i>Boa</i>	Boa/anaconda
<i>Euterpe precatoria</i>	<i>Huasai, chonta</i>	A tall palm tree
<i>Ficus</i> sp.	<i>Renaco</i>	Hardwood trees
<i>Hoplerhynchus unitaeniatus</i>	<i>Shuyo</i>	Aimara (a fish)
<i>Ipomoea batatas</i>	<i>Camote</i>	Sweet potato
<i>Iryanthera</i> sp.	<i>Cumala</i>	Tall timber trees
<i>Manihot esculenta</i>	<i>Yuca</i>	Manioc
<i>Mauritia flexuosa</i>	<i>Aguaie</i>	An abundant, tall palm tree
<i>Mazama</i> sp.	<i>Venado</i>	Deer
<i>Melanosuchus niger</i>	<i>Lagarto negro</i>	Black caiman
<i>Musa</i> sp.	<i>Plátano</i>	Plantain
<i>Mylossoma duriventre</i>	<i>Palometa</i>	Silver mylossoma (a fish)
<i>Nasua nasua</i>	<i>Achui</i>	Ring-tailed coati
<i>Pachira brevipes</i>	<i>Jiri benüna</i> (in Urarina, i.e., "wood of the jiri")	A hardwood tree
<i>Pecari tajacu</i>	<i>Sajino</i>	Collared peccary
<i>Penelope jacquacu</i>	<i>Pucacunga</i>	Spix's Guan (a bird)
<i>Pithecia monachus</i>	<i>Huapo negro</i>	Monk saki (a monkey)
<i>Prochilodus nigricans</i>	<i>Boquichico</i>	Black prochilodus (a fish)
<i>Psittaciformes</i>	<i>Loro</i>	Parrot
<i>Psophia crepitans/leucoptera</i>	<i>Trompetero</i>	Grey-winged or Pale-winged Trumpeter (a bird)
<i>Saimiri boliviensis</i>	<i>Fraile</i>	Black-capped squirrel monkey
<i>Simarouba amara</i>	<i>Marupá</i>	A tall timber tree
<i>Swietenia macrophylla</i>	<i>Caoba</i>	Mahogany
<i>Tapirus terrestris</i>	<i>Sachavaca</i>	Tapir
<i>Tayassu pecari</i>	<i>Huangana</i>	White-lipped peccary
<i>Tinamus major</i>	<i>Perdiz</i>	Great Tinamou (a bird)
<i>Virola</i> sp.	<i>Cumala</i>	Tall timber trees
<i>Zea mays</i>	<i>Maíz</i>	Corn

Additionally, each interview included an individual map-making element, in which interviewees described the areas they had visited, again in view of identifying a local classification system, and the socio-cultural importance of each ecosystem type.

Finally, we also conducted 3 site visits to the various ecosystem types that we identified (see *Urarina ecosystem classification*) with the guidance of 5 different community members. During these site visits, we had the opportunity to clarify certain characteristics of each ecosystem type in practice and what distinguished ecosystems from each other, especially during the act of crossing from one ecosystem into another. We were also

able to collect photographic evidence of the variations in the surrounding environment (see sample photographs in Figs. 2-5). Not least, we were also able to verify with reasonable certainty which ecosystems could be described as peatlands, typically defined as waterlogged areas with at least 30 cm of organic-rich (> 65 wt% organic matter) soil (Lawson et al. 2015, Dargie et al. 2017), and which ecosystems were not, by probing the ground with poles; these can be pushed easily into waterlogged peat, which has a low dry bulk density, typically below 0.15 g/cm³ (Lawson et al. 2015), but not into soils containing a higher percentage of mineral matter such as silt and clay.

Fig. 2. A *jiiri*; this ecosystem consists of “open space” with short vegetation and very soft, waterlogged ground, but note that the *jiiri* ecosystem may have very diverse appearances.



URARINA ECOSYSTEM CLASSIFICATION

Our investigation of Urarina ecosystems yielded a list of 8 main ecosystem types that are recognized by most community members (see Table 2), of which 2 at least sometimes contain peats up to 1.5 m in thickness and which may be consistently peat forming. We briefly describe each ecosystem type; Urarina spellings were confirmed with a local school teacher who had been involved in developing the officially recognized Urarina orthography. A preliminary list of ecosystem types was developed following the participatory mapping workshop with the entire community at the beginning of our fieldwork, with some ecosystems being added during individual interviews with community members. To identify each ecosystem’s unique features and characteristics, we covered a number of potential indicators during interviews, such as vegetation, i.e., physiognomy and species composition; water regime, i.e., seasonal flooding patterns; soils, i.e., color, muddiness, and “sinkiness”; topography; and human uses, i.e., hunting, fishing, and small-scale farming. Because of our special focus on peatlands, we also included questions on walking experiences, i.e., whether it was easy or difficult to walk in each respective ecosystem, and whether there were problems because of sinking in or having one’s boots “sucked” in (in local Spanish:

Fig. 3. An *alaka*; this ecosystem is defined by the mix of large trees and palm trees, as well as the permanently waterlogged peat soil.



chupadera). Note that for animal and plant species, English names are used where available, and local Spanish names where not. On first appearance, these are complemented with the scientific name (see also Table 1).

Jiiri

The *jiiri* ecosystem is highly variable in its appearance (see Fig. 2 for an example). It may include small lakes and ponds, areas of grasses and sedges, a mix of *aguaje* palm trees with areas of pole forest, i.e., closely spaced, low stature, thin-stemmed trees, known to ecologists in Spanish as *varillal* (Draper al. 2014, 2018), or pole forest without *aguaje*. This variability may be explained by the fact that the term *jiiri* represents a rather abstract concept; several interviewees indicated that its meaning is roughly equivalent to “open space.” Consequently, no single translation into local Spanish was given either; the terms *aguajal* (palm swamp), *varillal* (pole forest), and *pantano* (open wetland) were all mentioned in interviews, but there was no clear consensus about the most appropriate translation for *jiiri*. *Aguajal* was the most commonly favored Spanish equivalent, but it was also used for the *alaka* ecosystem (see *Urarina ecosystem classification: alaka*).

Despite covering different vegetation patterns, compositions, and structures, all *jiiris* are similar in that their soil shows the

Fig. 4. The ground in an *elelia*. This ecosystem consists of mostly dryland forest dominated by the *Attalea butyracea* palm species; standing water does exist but is much rarer than in the *alaka* ecosystem.



characteristics typical of local peatlands: (1) One can sink in easily; probing during one site visit indicated the presence of at least 1.5 m of peat, although our guide indicated that the peat thickness may vary between *jiiris*. (2) They are permanently waterlogged, though only occasionally flooded by river water. (3) Their pore water is dark and transparent, indicating high concentrations of dissolved organic matter. Colors given for the soil ranged from “reddish,” which is typical of unhumified peats, to black, which is typical of more decomposed peats. To avoid sinking in, one needs to step on roots of trees wherever possible or cut branches or small trees to walk on where available.

Short trees from *jiiri* forest can be used for construction, mainly as roof pillars. Some respondents suggested monkeys could be hunted in *jiiris*, whereas others said this was not possible because of the absence of trees, this disagreement likely being the result of the variability of *jiiri* appearances. However, there was a consensus that the *jiiri* is a good hunting ground for tapirs (*Tapirus terrestris*) and caimans (*Caiman crocodilus* and *Melanosuchus niger*); tapirs may sleep and rest in *jiiris*, whereas caimans usually stay in the little ponds that make up part of a *jiiri*. Lizards (*Dracaena guianensis*) and parrots (Psittaciformes), which in the past were occasionally sold alive to wildlife traders from Iquitos,

Fig. 5. A *leuuaku*; this ecosystem consists of seasonally flooded forest.



were further mentioned as animals from the *jiiri* ecosystem. It is also an area where anacondas (*Eunectes murinus*) can be found, which may only be killed in extremely rare instances of self-defense.

Respondents differed markedly in their assessment of the importance of *jiiris* for local people. Some highly valued them as a hunting ground and source of *aguaje* fruit and stressed their cultural importance (see *Interpreting indigenous perspectives on ecosystem classification and peatlands: cultural significance of tropical peatlands*); others highlighted the difficulties of the terrain and comparatively lower resource availability and expressed a clear preference for *alaka* and *atane* ecosystems, among others.

Alaka

The *alaka* ecosystem is characterized by the dominance of *aguaje* palm trees, which are interspersed with other large timber trees, such as *cumala* (*Virola* sp. or *Iryanthera* sp., known as *kaiajuri* in Urarina), and further palm tree species such as *shebón* (*Attalea butyracea*) or *ungurahui* (*Oenocarpus bataua*). *Alaka* is thus notably darker than *jiiri*, as less light passes through the canopy (see Fig. 3). It is possible that the name *alaka* derives from the Urarina word for *aguaje*, which is *alaa* (see also Balslev et al. 2008), but some interviewees explicitly disputed this. Because of the dominance of *aguaje* palm trees, some respondents used the terms *alaka* and *aguajal*, i.e., *Mauritia flexuosa* palm swamp (see Gilmore et al. 2013), interchangeably. Nevertheless, others suggested that *jiiris* are *aguajales*, too, so *alaka* should not be seen as an exact translation of *aguajal*.

The ground in *alakas* is again characteristic of a peatland; one can easily sink in, although not necessarily as much as in *jiiris*; probing during guided site visits showed the presence of > 1.5 m of peat, and it was often necessary to step on roots or felled small trees to avoid sinking in. *Alakas* are permanently wet, with less standing water than in *jiiris*, but are only rarely flooded by river water and must therefore be fed by rainfall and/or groundwater. The soil pore water is transparent but very dark in color, and the

Table 2. Summary of the characteristics of ecosystem types identified by Urarina interviewees. Where flooding is indicated, this was described as flooding by rivers. “Mud,” *fango* or *barro* in local Spanish and *itanicha* in Urarina, is taken to indicate soft substrates that may include peats and wet clayey and silty soils. Possible equivalent terms from the scientific literature on Peruvian wetland vegetation are tentatively indicated, as are the probable equivalent land-cover classes from Draper et al. (2014), although no formal attempt was made in the field to test their strict equivalence.

<i>Jiiri</i>	<i>Alaka</i>	<i>Atane</i>	<i>Elelia</i>	<i>Leuaku</i>	<i>Jierune</i>	<i>Kaiajurineejua</i>	<i>Ujuarineejua</i>
Approximate English equivalent “Open space”	Palm swamp forest	Dryland forest	Mostly dryland forest dominated by <i>Attalea butyracea</i> (<i>shebón</i> , a palm species)	Seasonally flooded forest	Riparian seasonally flooded low-growth forest	Palm swamp forest dominated by <i>Virola</i> sp. or <i>Iryanthera</i> sp. (<i>cumala</i> , a timber tree)	Palm swamp forest dominated by <i>Euterpe precatoria</i> (<i>huasai</i> or <i>chonta</i> , a palm species)
Vegetation physiognomy Highly variable, ranging from grassland to short, thin trees and palm trees	Mix of large timber trees and palm trees	Mix of large timber trees and palm trees	Mix of large timber trees and palm trees	Mix of large timber trees and some palm trees	Short trees and bushes, lianas, very dense vegetation	Mix of large timber trees and palm trees	Mix of large timber trees and palm trees
Important (palm) tree species with local Spanish name <i>Mauritia flexuosa</i> (<i>aguaje</i>)	<i>Mauritia flexuosa</i> (<i>aguaje</i>) <i>Virola</i> sp. or <i>Iryanthera</i> sp. (<i>cumala</i>) <i>Attalea butyracea</i> (<i>shebón</i>)	No single dominant species, but many timber species	<i>Attalea butyracea</i> (<i>shebón</i>)	<i>Ficus</i> sp., <i>Coussapoa</i> sp. (<i>renaco</i>)	No single dominant species	<i>Virola</i> sp. or <i>Iryanthera</i> sp. (<i>cumala</i>)	<i>Euterpe precatoria</i> (<i>huasai</i> or <i>chonta</i>)
Hydrology Permanently wet soils because of groundwater, occasional flooding from river water	Permanently to seasonally wet soils (but less wet than <i>jiiri</i>) because of groundwater and rainfall, rarely flooded from river water	Rarely flooded	Rarely flooded	Flooded for several months each year by river water	Flooded for several months each year by river water	Uncertain, but likely similar to <i>alaka</i>	Uncertain, but likely similar to <i>alaka</i>
Soil and water color Red to black soil, deep mud, water layer sometimes present beneath root mat	Black to brown soil, deep mud	Brown sandy soil, little mud except after heavy rain	Brown to black soil, shallow muds at most	Brown to black soil, muddy only when flooded	Uncertain, but likely similar to <i>leuaku</i>	Black soil	Uncertain, but likely similar to <i>alaka</i>
Maximum “sinking in” level Up to chest	Up to waist	None	Feet	Feet	None	Up to knees	Above ankles
Main human uses <i>Mauritia flexuosa</i> (<i>aguaje</i>): fruit, fiber for textiles Poles for construction/ roof structures, e.g., <i>Pachira brevipes</i>	<i>Mauritia flexuosa</i> (<i>aguaje</i>): fruit, fiber for textiles Timber for construction (floors, walls), e.g., <i>Virola</i> sp. or <i>Iryanthera</i> sp.	Timber for construction and trade, e.g., <i>Swietenia macrophylla</i> (mahogany), <i>Cedrela odorata</i> (cedro), <i>Calycophyllum spruceanum</i> (<i>capirona</i>)	<i>Attalea butyracea</i> (<i>shebón</i>): leaves for roofing	Various timber tree species, e.g., <i>Calophyllum brasiliense</i> (<i>lagarto caspi</i>); firewood	Poles for construction/ roof structures	<i>Virola</i> sp. or <i>Iryanthera</i> sp. for construction	<i>Euterpe precatoria</i> (<i>huasai</i> or <i>chonta</i>): palm hearts

(con'd)

Hunting for <i>Tapirus terrestris</i> (tapir), <i>Caiman</i> <i>crocodilus</i> , <i>Melanosuchus</i> <i>niger</i> (spectacled and black caiman)	Hunting for terrestrial mammals, e.g., <i>Tapirus terrestris</i> (tapir), <i>Pecari</i> <i>tajacu</i> (collared peccary), <i>Tayassu</i> <i>pecari</i> (white- lipped peccary); monkeys, e.g., <i>Saimiri boliviensis</i> (squirrel monkey), <i>Alouatta seniculus</i> (red howler); and birds, e.g., <i>Penelope jacquacu</i> (Spix's Guan)	Hunting for terrestrial mammals, e.g., <i>Mazama</i> sp. (deer), <i>Cuniculus paca</i> (lowland paca), <i>Dasyprocta</i> <i>fuliginosa</i> (black agouti), <i>Dasyprocta</i> <i>novemcinctus</i> / <i>kappleri</i> (armadillo); <i>Chelonoidis</i> <i>denticulata</i> (yellow-footed tortoise), monkeys, and birds, e.g., <i>Psophia crepitans</i> / <i>leucoptera</i> (Grey- winged or Pale- winged Trumpeter), <i>Tinamus major</i> (Great Tinamou)	Hunting for the same animals as in <i>atane</i>	Fishing with traps, for example: <i>Hoplerhythrinus</i> <i>unitaeniatus</i> (shuyo), <i>Brycon</i> sp. (sábalo), <i>Prochilodus</i> <i>nigricans</i> (boquichico), <i>Biotodoma</i> sp. (bujurqui), <i>Mylossoma</i> <i>duriventre</i> (palometa)	Fishing with traps		
	Seeds for necklaces		Seeds for necklaces				
Alternative names in Peruvian Amazonian Spanish (not necessarily strictly equivalent)							
<i>Varillal, aguajal, pantano</i>	<i>Aguajal, shebonal</i>	<i>Restinga, yarinal</i>	<i>Shebonal</i>	<i>Bajial, tahuampa, renacal</i>	<i>Bajial, tahuampa, sogal</i>	<i>Cumalar</i>	<i>Chontal</i>
Scientific literature equivalent(s)							
“Open peatland,” “open savanna” (Lähteenoja et al. 2009), pole forest/ <i>varillal</i> <i>hidromórfico</i> (Draper et al. 2014, 2018)	Palm swamp, <i>aguajal</i> (Encarnación 1985, Junk and Piedade 2010)	Terra firme forest	Not formally described	Black water seasonally flooded forest, <i>tahuampa</i> (Encarnación 1985)	Riparian seasonally flooded forest, gallery forest	Not formally described	Not formally described
Equivalent land-cover classes of Draper et al. (2014)							
Encompasses two classes: open peatland and pole forest	Palm swamp	Terra firme/ occasionally flooded forest	Terra firme/ occasionally flooded forest	Seasonally flooded forest	Seasonally flooded forest	Palm swamp	Palm swamp

soil color was described as ranging from brown to black by respondents.

The relatively abundant and large *cumala* trees are used for construction, e.g., for the floors and walls of houses. One can also find the same small trees for roof structures that are characteristic of *jiiris*, in between the larger trees. *Alaka* is comparatively better hunting ground than *jiiri*, e.g., for tapirs, peccaries, lowland pacas, agoutis, coatis, sloths, and tortoises, as well as monkeys such as howler monkeys, squirrel monkeys, or monk sakis (see Table 1 for all scientific names), many of which are attracted by *aguaje* fruit and large trees more generally. It is also the ecosystem of choice for the harvesting of *aguaje* fruit and fiber, for commercialization and domestic textile production, respectively. During *aguaje* harvesting season, local people may visit *alakas* to cut *aguaje* palm trees and sell fruit to traveling traders. Urarina women gather seeds in *alakas* that they use for decoration and necklaces.

Because of the uses of *alakas* for hunting and harvesting of timber, fruit, and other nontimber forest products, interviewees generally attributed high importance to them and would regularly visit them. Not least, hunters would regularly have to cross *alakas*

anyway, given that they surrounded the community where fieldwork took place.

Atane

This ecosystem is named after the Urarina word for “earth,” which is *atane*. The defining feature of this ecosystem is the absence of prolonged flooding, i.e., beyond 1-2 days per year, or waterlogging of soils, in contrast to *jiiri*, *alaka*, and, to a lesser extent, *elelia*. The soil is usually brown, firm, and dry. If untouched, *atane* is generally covered in rain forest with large trees, but it is also the preferred location for setting up *chacras*, small-scale agricultural fields, and the communities themselves. *Atane* is close to synonymous with what is called *restinga* elsewhere in Peruvian Amazonia (Encarnación 1985), and many respondents used the two words interchangeably.

Atane is the most valuable ecosystem for the Urarina, as they grow their crops and build their houses in it. However, uncultivated *atane* areas are also highly valued as the best available hunting grounds. Many respondents suggested that “all animals can be found in *atane*,” including all locally known monkey species; some further noteworthy game species are deer, peccaries, agoutis, and

armadillos, as well as a variety of bird species, such as Spix's Guans, Grey-winged or Pale-winged Trumpeters, and Great Tinamous, which are less common in *alaka* and cannot usually be found in *jiiris* (see Table 1 for scientific names). *Atane* also offers the best variety of timber tree species for construction, including, but not limited to, *cumala* (i.e., *Virola* sp. or *Iryanthera* sp. of better quality than *cumala* from *alaka*), mahogany (*Swietenia macrophylla*, known as *caoba* in local Spanish), *cedro* (*Cedrela odorata*), *marupá* (*Simarouba amara*), *copaiba* (*Copaifera officinalis*), or *capirona* (*Calycophyllum spruceanum*). Older respondents noted a strong decline in the availability of these commercially valuable trees over the past few decades, although *capirona* could potentially be managed, as is already the case elsewhere in the Peruvian Amazon (Weber and Sotelo Montes 2005, Sotelo Montes et al. 2008).

Atane is considered a scarce and, in this sense, valuable ecosystem type among local community members. This was made clear in interviews when some respondents reported having to travel more than an hour to reach their *chacras* in an *atane* area. Furthermore, the search for *atane* motivated a move of the entire community about 25 years ago, as the previous location, about 30 minutes downstream by engine-powered canoe, or *peque peque*, did not offer enough *atane* for the growing population to build houses. Moving communities is a common practice among the Urarina, and although it is possible to protect houses from flooding by building them on stilts, the Urarina still exclusively choose to build communities in nonflooded, i.e., *atane*, areas, as Kramer (1979) noted 40 years ago. Indeed, a neighboring Urarina community had just moved to a different location shortly before we visited.

Elelia

The *elelia* ecosystem is dominated by the palm tree species locally known as *shebón*. Very likely, the name derives from the Urarina word for this palm tree, which is *ele*. In its appearance, *elelia* has similarities with *alaka* and *atane*, i.e., palm trees are mixed with other large trees, and *elelia* is only rarely flooded by river water. The soil ranges in color from brown to black and is less soft underfoot than in *jiiri* or *alaka*, probing being possible only to a depth of ~20 cm (see Fig. 4). Although the soil is typically moist, standing water is much rarer than in *alaka*. Respondents noted that one cannot typically find *aguaje* in *elelia*, although other palm trees such as *huasá* or *chonta* (*Euterpe precatoria*) are present. The name *elelia* could be translated into Spanish as *shebonal*. Although the “sinky,” wet ground is superficially similar to peatland ecosystems, and respondents mentioned *elelia* alongside *jiiri* and *alaka* as an example of “muddy” places, i.e., potential peatland areas, the examples of *elelia* that we visited had too thin an organic soil layer to be considered as peat forming.

Elelia is an important place for the harvesting of *shebón* leaves, which are used to cover the roofs of traditionally built houses. It is also a good hunting ground, where most game species can be found, similar to *atane* and *alaka*. Respondents mentioned monkeys, birds, agoutis, and tortoises, among others. Some female interviewees also said they could find seeds for decoration and necklaces in this ecosystem. *Elelia* can be found right next to the community, but overall, it appears to cover less area than the ecosystems described in the previous sections.

Leuuaku

The *leuuaku* ecosystem (see Fig. 5) shares many characteristics with *atane*, including the brown color of its soil, which is solid and dry when not flooded, as well as the vegetation cover consisting of mainly large trees, mixed with some shorter trees, and some palm trees. The main difference is that *leuuaku* is seasonally flooded by river water, because it is located at a lower topographic level than *atane*. In this sense, “seasonally flooded forest” might be an appropriate translation into English. In contrast to the *atane* ecosystem, *renaco* trees, i.e., large trees with aerial roots, such as *Coussapoa* sp. and *Ficus* sp., which are well adapted to seasonal flooding, can be found in *leuuaku*. Some interviewees mentioned that *leuuaku* is synonymous with what is called *tahuampa* elsewhere in the Peruvian Amazon, i.e., flooded forest, or alternatively, *bajial*, i.e., a low-lying area prone to flooding (Encarnación 1985). However, although very similar in meaning, these terms cannot be considered synonymous, because they miss the more fine-grained differences with the *jierune* ecosystem (see *Urarina ecosystem classification: jierune*). Furthermore, the term *tahuampa* is only applied to seasonally flooded forest when flooded (Encarnación 1985), whereas *leuuaku* is recognized as *leuuaku* even when not currently flooded. Because of the solid ground, it appears unlikely that the *leuuaku* ecosystem is typically peat forming, which agrees with the provisional view from the limited scientific surveys that peat-forming seasonally flooded forests, though not unknown, are rare in Peruvian Amazonia (Draper et al. 2014).

The main resources of *leuuaku* are fish, which are caught with traps when the area is under water and the fish can feed on fruit and seeds from flooded trees. Examples of common fish species found in *leuuaku* are *shuyo* (*Hoplerythrinus unitaeniatus*), *sábalo* (*Brycon* sp.), *boquichico* (*Prochilodus nigricans*), *bujurqui* (*Biotodoma* sp.), or *palometa* (*Mylossoma duriventre*). When not flooded, in a similar way to *atane*, *leuuaku* can be used for hunting. One can also find wood and timber, most importantly *lagarito caspi* (*Calophyllum brasiliense*), but also *capirona* and *cumala*, among others. *Leuuaku* is popular for collecting firewood, and no respondent considered this ecosystem to be unimportant.

Jierune

The *jierune* ecosystem can typically be found just next to rivers and streams. It is a low-lying area covered in thick vegetation of small trees and bushes and is seasonally flooded just like *leuuaku*. Some respondents had difficulties in specifying the differences between *jierune* and *leuuaku*, and others suggested that the name could be translated again as *bajial* or *tahuampa* (see *Urarina ecosystem classification: leuuaku*). Nevertheless, it appears that *leuuaku* and *jierune* are distinguished by their location (i.e., *jierune* is more likely to be located immediately next to a river) and vegetation physiognomy (i.e., *jierune* has much more dense vegetation with a much lower canopy, on average). *Jierune* may also contain some *renacos*, i.e., individual large trees with large aerial roots, and lianas, and one interviewee suggested that *jierune* could be translated as *sogal*, i.e., area where lianas grow.

Jierune is difficult to walk or hunt in because of the density of the vegetation; similarly, local people prefer putting fish traps in *leuuaku*, rather than *jierune*. Thus, it is less important in terms of resources than other ecosystems, which may also explain why some interviewees were reluctant to describe uses and detailed

characteristics of this ecosystem. Nevertheless, *jierune* is a potential source for small trees that can be used for construction, especially roof structures, similar to *jiiri*.

Kaiajurineejua

The *kaiajurineejua* ecosystem is defined by an abundance of *cumala* trees (*Virola* sp. or *Iryanthera* sp.), called *kaiajuri* in Urarina. The suffix *neejua* likely means “a lot” in this context. Beyond the abundance of *cumala*, *kaiajurineejua* seems to be very similar to *alaka*; that is, it is a mix of large timber trees and palm trees, with dark and possibly “sucking”, i.e., *chupadera*, ground. It is unclear whether *kaiajurineejua* should be seen as an ecosystem type at the same hierarchical level as, for example, *alaka*, or whether it represents merely a slight floristic variation within *alaka*; it was reported by some respondents to be located “inside *alaka*.” Nonetheless, the distinction is important to the local community because *cumala* appears to be the most popular timber tree species, used for house floors and walls and occasionally sold to traders. Most interviewees also readily translated *kaiajurineejua* into local Spanish as *cumalar*, i.e., place where *cumala* trees grow. This ecosystem may be peat forming given the cited soil characteristics and overall similarity with *alaka*. However, it was not possible to visit a *kaiajurineejua* during site visits. Like *elelia*, this ecosystem appears to cover only smaller areas.

Ujuarineejua

The *ujuarineejua* ecosystem is characterized by an abundance of *huasai* or *chonta* (*Euterpe precatoria*), called *ujuari* in Urarina. Again, respondents mentioned that it may be located “inside *alaka*”; that is, it is again unclear whether *ujuarineejua* should be seen as a separate ecosystem or, rather, a subtype of *alaka*. The name could be translated as *chontal* into local Spanish. Overall, we do not have much information about *ujuarineejua*, as respondents noted that it is not very common in the area. It was not mentioned during the participatory mapping workshop with the whole community at the beginning of our fieldwork, but rather in individual interviews with community members, and we were unable to visit it in person to verify its characteristics. Nevertheless, *ujuari*, or *chonta*, represents an important economic resource for local community members because it is harvested for its palm hearts and occasionally sold to visiting traders. In the study location, however, it appears that *ujuari* is mainly harvested from other ecosystems such as *elelia*, where individual palm trees of this species can be found.

INTERPRETING INDIGENOUS PERSPECTIVES ON ECOSYSTEM CLASSIFICATION AND PEATLANDS

Having presented an Urarina classification of the ecosystems of their surrounding environment in the preceding section, we connect our findings to broader academic debates. As outlined in the introduction, our findings may be of relevance to at least four broad themes, i.e., place naming, cultural heritage conservation, dialogue with scientific knowledge, and ecosystem management and conservation.

Naming places and ecosystems

Evidently, no single criterion is used in the Urarina ecosystem classification system to delimit the boundaries between various ecosystems. Important abiotic indicators include the hydrologic regime, e.g., to delimit the boundary between *atane* and *leuuaku*, and soils, which are the unifying feature across the various forms

of *jiiri*. Topography matters in so far as it may determine flooding levels. Important biotic factors are individual palm tree species (*aguaje*, *shebón*, and *chonta*); the tree species *cumala*, which could be understood as “cultural keystone species” (Garibaldi and Turner 2004; see *Interpreting indigenous perspectives on ecosystem classification and peatlands: cultural significance of tropical peatlands*); but also vegetation physiognomy, e.g., because *jierune* is defined by shorter and denser vegetation than *leuuaku*.

Competing theories for the development of landscape terminology exist, which are likely to be relevant for ecosystem terminology more specifically as well. Levinson (2008), for example, suggests that perceptual salience of certain features, human uses, and cultural factors may all play a role (cultural factors are discussed subsequently). Clearly, all three factors are relevant, although it may sometimes be difficult to determine their relative importance. For example, *jiiris* are perceptually different through the reddish to black ground where one can only walk with great difficulty, as well as the comparatively lower height of the vegetation; however, they are also known as hunting grounds for caimans and tapirs and could in this way be interpreted as a resource area. Similarly, the main difference between *atane* and *leuuaku* is the presence of seasonal flooding in the latter, but *leuuaku* is also known for the abundance of fish as a specific resource that can be caught with traps when flooded. Thus, salience and human uses are closely interwoven.

Conversely, *elelia*, *kaiajurineejua*, and *ujuarineejua* are primarily known as specific places to locate a certain natural resource and, in this sense, could be interpreted as “resource islands” embedded in the broader environment, such as, e.g., “the forest” (Posey 1985, Gilmore et al. 2013). Their simple definition as a “place where dominant resource plant species X can be found” is similar to naming conventions elsewhere in the Amazon, as reported by, e.g., Wartmann and Purves (2018), who also found that a large number of indigenous ecosystem types were named after a single plant species. This is in fact similar to naming practices in the English language, too, where one may speak of, e.g., “oak forest” or “beech forest.”

Cultural significance of tropical peatlands

As Levinson (2008) noted, cultural factors may also play a significant role in developing classificatory systems for landscapes and ecosystems. We place special emphasis on the cultural significance of peatland areas, an understudied field of research across tropical climate zones. Furthermore, this aspect of the research also contributes to documenting a relevant aspect of Urarina culture that might be at risk of being lost through cultural assimilation, this documentation and “safeguarding” being the objective of much research on indigenous knowledge (Shepard et al. 2001, Hance 2015, Ens et al. 2016).

As is common elsewhere in the Amazon, the Urarina traditionally believe in mythical creatures, spirits, “mothers,” or owners that inhabit certain ecosystems (Kamppinen 1988, Larochelle 2012, Combetti et al. 2015, Smith 2015, Burton 2018). For example, the “mother” of the *leuuaku* is said to be an anaconda. These spirits have supernatural powers and are typically feared for their evil character and tricks, but they are also seen as “defenders” of their particular ecosystem. In this way, they may serve as deterrents for environmentally unsustainable behavior, e.g., overharvesting of natural resources or hunting (Larochelle 2012, Burton 2018).

Interestingly, one such “mother” or spirit recognized by the Urarina, the Baainu, lives in both *alaka* and *jiiri* ecosystems, i.e., the two main ecosystems that are most likely peatland ecosystems. As many interviewees testified, the Baainu may make people lose their way in the *jiiri* and *alaka* by calling an unlucky person’s name, disguising its voice, and pretending to be a family member. Ultimately, the Baainu seeks to transform the (human) person into a Baainu. The Baainu may also steal items from hunters, such as machetes. The name Baainu might be related to witchcraft, given that Dean (1999) translates the word *bainee* as “sorcery.” The Baainu’s strategy was told to us as follows by one community member:

Sometimes, when the Baainu wants to take you, and you are following some animal, such as a white or black monkey, he will confuse you and you follow the animal, thinking that you’re going a short distance, when actually, it is not. “Where is it?” you start wondering. Jiiri and alaka have the same mother, and he [i.e., the mother/ Baainu who is both male and female] takes you to his very nice house, the pillars of which are built with the trunk of an aguaje palm tree. Under it, you can see aguaje fruit that he will eat. There are also white monkeys sitting on both shoulders of the mother, and an animal that looks like a jaguar can be seen, too, chained and with its mouth well tied up. Your family members will be looking for you, but the Baainu will tell you not to listen to the noise and he will confuse you. You will see a beautiful house, nice houses, and it does not appear muddy. You can feel that there is a good soil, and the houses look really very nice. The animal from the Baainu’s shoulder will want to jump on your shoulder and sit there; but if it does jump and sits on your shoulder, you will never see your relatives ever again. Your family will look for you and for someone who knows how to drink ayahuasca, and through that [i.e., drinking ayahuasca], the Baainu will say: “Before I make you eat with these animals, I will take you to your house, so you can go home. I don’t like it when they call me like this.” Having said that, he will take you and put you back to the place where he found you. [...] But if your family does not search for you, well, then you will stay there forever.

Not all interviewees were willing to answer questions about the Baainu, and some stated that they had no knowledge of it; this reluctance to respond or loss of knowledge may potentially be related to the loss of traditional belief systems or their replacement with evangelical Christian beliefs, introduced by Argentinean and U.S. missionaries (Olawsky 2006). In other cases, people may have not been willing to share their personal beliefs with a stranger. The Baainu story has many similarities with the traditional belief in the Chullachaqui across Amazonia, an evil spirit that makes people lose their way by taking up the appearance of a different person (Larochelle 2012, Smith 2015), known by many different names (Burton 2018). In contrast to the Baainu, however, the Chullachaqui is known as the “guardian spirit of the forest” (Larochelle 2012), i.e., it is not usually associated with palm swamp and peatland ecosystems such as *jiiri* and *alaka*. The Maijuna of the Peruvian Amazon do know an evil spirit that lives in palm swamps, the Gogobai, who may abduct local people (Gilmore et al. 2013). However, the Gogobai aims to

eat its victims, which is not the case for the Baainu. Thus, each mythological figure has some unique features, and descriptions even for the same spirit may vary between people and communities (see also Walker 2013b). This suggests that indigenous knowledge is not “fixed,” and that there is a contrast not only between indigenous and scientific knowledge but also between various indigenous knowledges, i.e., between different indigenous peoples, as well as within one indigenous nation. In this sense, indigenous knowledge should be seen in relational terms, rather than space bound and clearly defined (Andolina et al. 2009). It also implies that our description of the cultural heritage, as well as of the Urarina ecosystem categories themselves, can always only be an approximation or simplification of the diversity of indigenous knowledges.

Beyond the Baainu spirit of *jiiri* and *alaka*, peatland areas have further special cultural significance to the Urarina, given that they are the source of *aguaje* palm tree fiber, which Urarina women use for the production of traditional textiles, known as *cachihuango* elsewhere in the Peruvian Amazon (Morales Chocano 2004). These textiles are of central importance to Urarina culture and cosmology, and in this way, *aguaje* could be understood as a “cultural keystone species,” given the central importance of this species for both ecology and culture in the area (Garibaldi and Turner 2004). Dean (1994) recounts the Urarina creation myth, which involves an episode in which the distinction between “ignorant” and “wise” women is described as their ability to make palm-fiber cloth. The practice of weaving these palm-fiber cloths continues today, even if most Urarina women now wear clothes made from cotton.

Lessons learned for ecology and conventional science

The Urarina ecosystem classification gives valuable insights and inspiration for further scientific research, and in this way, it can serve as a reference framework for comparison, ground truthing, and learning, as noted by many ethnoecologists (Fleck and Harder 2000, Shepard et al. 2001, Abraão et al. 2008, Fernández-Llamazares et al. 2017, Reyes-García et al. 2018). Scientific description and mapping of the vegetation of Peruvian Amazonia is an active field of research. Community ecologists recognize that vegetation classifications are necessarily a simplification of reality, but they are widely used for pragmatic purposes. Various terms for different categories of vegetation or landscape units have been introduced into the literature (see examples in Table 2), usually informally, with different classification schemes developed for different purposes. One example is the large-scale mapping of Draper et al. (2014) aimed at identifying vegetation associated with peat and hence at modeling the distribution of above- and belowground carbon storage. It used a simple sevenfold classification of land-cover types, i.e., terra firme/ occasionally flooded forest, seasonally flooded forest, open peatland, peatland pole forest, palm swamp, bare ground, and open water, which focuses on reflectance properties that are visible in optical satellite imagery and on hydrologic properties that can be inferred from satellite-based radar data. Draper et al. (2018) later showed that distinctions between peatland pole forest, palm swamp, and terra firme forest, defined in the same way, are supported by floristic survey data; that is, the species composition of each vegetation type is substantially different. It would be highly desirable to carry out similar floristic inventories in the various ecosystems identified by the Urarina, which would

potentially be another opportunity for learning from indigenous environmental knowledge (see also Abraão et al. 2008).

Comparison of the terms used by Draper et al. (2014, 2018) and the Urarina (Table 2) suggests both similarities and differences. The Urarina appear to consider both “open peatlands” and “peatland pole forest” to be constituents of *jiiri*, perhaps because the structural mix of herbs, shrubs, and trees shows rather continuous variation and because the types of resources, such as caiman and tapirs, found throughout the *jiiri* are the same. From a scientific point of view, the ecological and floristic relationships between open peatlands and peatland pole forests remain an open question: To our knowledge, no formal botanical description of an open peatland has yet been undertaken, and it is not yet clear whether the two (possibly end-member) environments typically form part of a temporal succession or some other kind of physical or chemical gradient. Conversely, our interviewees named two subcategories of palm swamp, *kaiajurineejua* and *ujuarineejua*, which are characterized by particular tree species that are important resources to them. The prevailing scientific classification risks playing down the significance of the swamp forests for the people who rely on them for their subsistence. The Urarina ecosystem classification explicitly incorporates human ecology and is in this sense more holistic than current scientific classification systems as is often the case in indigenous or traditional ecosystem classifications (Berkes et al. 1998).

The terms “open peatland” and “peatland pole forest,” increasingly important in the scientific literature on carbon storage, do not have direct equivalents in the Urarina language, which poses a challenge for scientists in communicating with local community members. However, it is also interesting that although peat itself does not have any local uses, unlike in northern countries such as Scotland or Finland, it seems that the boundary between *jiiri* and *alaka* on the one hand, and other ecosystem types on the other, does indeed coincide with the presence of peat in the ground. Further interdisciplinary research would be desirable to establish whether there is such a link between indigenous knowledge and scientific understanding of soils.

Ecosystem management, conservation, and socioeconomic development implications

As many scholars have noted, studying indigenous knowledge may contribute to better ecosystem management and environmental conservation (Stevenson 1996, Berkes et al. 2000, Chapin 2004, Folke 2004, Sheil and Lawrence 2004, Puri 2007, Sileshi et al. 2009). On a very basic level, learning an indigenous terminology may help with communication across cultural and epistemological differences (Omotayo and Musa 1999). Any outside actor engaging in environmental management and conservation activities in Urarina territory will benefit from understanding that the community has a sophisticated view of its own environment, reflecting the value of the many resources that the community uses through local ways of classifying the environment, and that it does not see the environment in exactly the same way as scientists or development workers schooled in a different tradition. Better communication between outsiders and local communities may make for more effective collaborations, with community priorities and aspirations better recognized from the outset and scientists better able to translate their ideas into mutually intelligible terms (Ens et al. 2016). There may also be

connections between spatial and temporal aspects, i.e., indigenous ecosystems and aspects of seasonality, or phenology, e.g., in the form of seasonal fishing activities in the *leuuaku* or harvesting calendars for particular resources, with potential implications for environmental management and adaptation to environmental change (Davidson-Hunt and Berkes 2003, Gómez-Baggethun et al. 2013, Armatas et al. 2016).

Our work has shown that much of Urarina culture is intimately linked to their environment. Myths, legends, and stories about the different ecosystems, such as the Baainu described previously, or the notion that certain plant species have “owners” or “mothers,” i.e., guardian spirits, which pose a threat to humans, but which, if respected, indirectly help with the conservation of natural resources (see *Interpreting indigenous perspectives on ecosystem classification and peatlands: cultural significance of tropical peatlands*), are shared, to a varying extent, among members of the community and thus are part of their social identity. This brings a human dimension to the landscape that is currently lacking from the literature on biodiversity and carbon conservation on Amazonian peatlands (Roucoux et al. 2017), although it has previously been noted that indigenous ecosystem classifications are often better suited to capture social-ecological dynamics than conventional ecology (Berkes et al. 1998). If we value diversity in human culture, the strong link between Urarina culture and their environment provides an additional reason for conserving, or at least carefully managing development in, Amazonia’s wetland environments.

The apparent respect for *jiiri* and *alaka* evidenced by their “ambiguous” cultural position, i.e., valued but also feared, suggests that there may be synergies between cultural protection and biodiversity and carbon conservation. In the current context of calls to vastly increase the scope of protected areas that limit or even exclude people (Wilson 2016), it is important that future research engages actively with the communities living in these areas. This is especially important in quantitative studies that aim to address how biodiversity and carbon stocks are affected by the presence and activities of indigenous and more recent settler communities. Emphasizing their voices in these studies will help strengthen their own management of diverse peatland-rich environments.

CONCLUSIONS

We have established the importance of taking indigenous ecosystem classification systems seriously in academic debates on tropical peatlands by showing how Urarina indigenous communities living in Peruvian Amazonia classify their peatland-rich and wetland-dominated environment. We found that the Urarina recognize at least 8 ecosystem types, which are defined by multiple biotic indicators, such as salient tree species and vegetation physiognomy, and abiotic indicators, such as hydrology, topography, and soils. This suggests that the Urarina do not place as much emphasis on single-species-defined ecosystems as other indigenous peoples in Amazonia, who distinguish 40 to 60 such ecosystems (e.g., Shepard et al. 2001, Wartmann and Purves 2018). Compared with existing scientific classification schemes, which are so far mostly based on floristic composition and vegetation structure (Draper et al. 2014, 2018), the Urarina ecosystems are more holistic and include human ecology as well.

This knowledge could potentially be used for communication between scientists and local people, as well as for improved environmental management and conservation. It could also be the basis for further participatory mapping exercises, including participatory GIS (Chapin et al. 2005, Olson et al. 2016) and detailed vegetation surveys in the various Urarina ecosystems, to gain a better understanding of the spatial aspects of the various ecosystems and traditional land uses and how they compare with existing remote-sensing-based maps and ecological classifications (i.e., Draper et al. 2014, 2018).

Two Urarina ecosystems, *jiiri* and *alaka*, appear to be peatlands and, moreover, hold a central position in Urarina culture as the home of the mythical creature called Baainu, which may trick and trap people who may get lost in the difficult terrain. Culturally, peatlands thus occupy an ambiguous position for the Urarina, because they are not only dangerous places but also places for hunting caimans and tapirs, where the commercially valuable *aguaje* fruit can be harvested, and where women can find *aguaje* fiber to produce traditional textiles. In this way, tropical peatlands may be similar to peatlands in European countries, which are also perceived as culturally ambivalent spaces (Lehtinen 2000, Byg et al. 2017). This may suggest that the particular geography of peatlands may shape human perceptions across cultural and climatic boundaries.

Describing an Urarina classification system also opens up the possibility to use these categories in future scientific research that aims to close some of the existing gaps that we have exposed. Abraão et al. (2008) have noted that already Amazonian ecosystem classification borrows heavily from local terms (e.g., Encarnación 1985). *Jiiri* and *alaka* could potentially become scientifically defined terms, in this way demonstrating that indeed boundaries between indigenous and scientific knowledge are arbitrary, and that the two can often complement each other very well.

Responses to this article can be read online at:
<http://www.ecologyandsociety.org/issues/responses.php/10886>

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